Literature Review: **Investigating the Role of Telemedicine in Managing Type 2 Diabetes in Rural Adults**

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ABSTRACT:

Introduction: Type 2 diabetes (T2D) is a growing concern in Canada and around the world leading to life-threatening complications if left untreated. Rural populations are disproportionately affected due to the inaccessibility of specialist care and diabetes self-management education (DSME). The use of telemedicine for the management of chronic disease is a growing field of research in recent years. This literature review investigates the role of teleconsultation with an endocrinologist for managing T2D in rural adults in North America.
Methods: A literature search on PubMed using appropriate search terms was conducted. Studies in rural North American communities involving teleconsultation with an endocrinologist and a component of DSME were included. The primary outcome measured was HbA1c.
Results: A total of six articles met inclusion criteria. No Canadian studies were identified. All studies found a significant decrease in the HbA1c measures after the telemedicine intervention.
Discussion: The findings of this literature review suggest that telemedicine is effective at reducing HbA1c measures in North American adults with T2D. However, given the small sample sizes and non-randomised control trials, further research is needed, especially in rural Canadian populations, to determine the role of telemedicine for T2D management and its implementation in rural Canada. Telemedicine has many advantages, including increased accessibility to specialist care and reduced travel costs to urban centres. Barriers to telemedicine include implementation difficulties, access to the internet and technology and security concerns.
Conclusions: Telemedicine for managing T2D is shown to be effective in reducing HbA1c measures in North American rural adults. However, further primary evidence is required to determine a causative effect.

KEYWORDS: Telemedicine, Telehealth, Teleconsultation, Rural, Type 2 Diabetes Mellitus

INTRODUCTION:

Type 2 Diabetes Mellitus

Diabetes mellitus (DM) is one of the highest leading causes of morbidity and mortality worldwide (1). Globally, there are 537 million individuals living with DM as of 2021 which is estimated to increase to 783 million by 2045 (2). Type 2 diabetes (T2D) accounts for 96% of all DM cases globally (1), and therefore, will be the focus of this study.

T2D is a chronic metabolic disorder characterised by insulin resistance with pancreatic beta-cell dysfunction leading to chronic hyperglycaemia (3). Glycated haemoglobin (HbA1c), which reflects average glucose over a three-month period, is an important measure of glycaemic control and management (4). Chronic hyperglycaemia damages multiple organs and causes life-threatening microvascular and macrovascular complications, which are divided into chronic and acute (3). Chronic complications of uncontrolled DM include neuropathy, nephropathy, retinopathy, peripheral vascular disease, coronary artery disease, and cerebrovascular disease (3). Acute complications of uncontrolled DM include hypoglycaemia, hyperglycaemic diabetic coma, hyperglycaemic hyperosmolar state, and diabetic ketoacidosis (3).

Diabetes Self-Management Education (DSME) interventions are shown to improve health outcomes and empower those with T2D (5). DSME involves counselling T2D patients on lifestyle modifications, including diet, exercise, smoking cessation, glucose monitoring, wound care, and medication adherence to improve quality of life and reduce associated complications (5). Additionally, providing patient-centred care through a collaborative multidisciplinary team approach involving endocrinologists, psychologists, nurses, primary care providers (PCP), nutritionists, and pharmacists has shown to produce better DM outcomes(6). These outcomes

include improved glycaemic control, improved mental health, improved CKD outcomes, reduced hospital admissions, reduced amputations, and reduced foot ulcers (6).

Barriers to Type 2 Diabetes Care in Rural Canada

According to Diabetes Canada, 30% of Canadians live with DM or pre-DM, while 10% have received a formal diagnosis (7). T2D accounts for 90% of all DM cases in Canada (8). Every 24 hours, 480 Canadians are diagnosed with DM, 20 people die of DM-related complications and 14 more have a lower limb amputation (8). The Canadian healthcare system spending $75 million treating diabetes daily (8). T2D is a growing concern for Canadians, especially those in rural or remote areas due to social disparities, including inaccessibility and lack of continuity of care (9).

In Canada, 60% of Indigenous peoples live in rural regions, which is 33% more than non-Indigenous peoples (10). The prevalence of DM in Indigenous adults is higher compared to non-Indigenous adults by a 1.72-fold increase in First Nations, a 1.22-fold increase in Metis, and a 1.18-fold increase in Inuit adults due to the continued effects of colonisation on their health (7).

Prinjha et al. (2022) found that social determinants of health (SDOH), including income, housing, employment, education, racism, social supports, food security, and most importantly, access to healthcare services, disproportionately affect those with DM and their families (11). The accessibility of healthcare services is directly associated with improved glycaemic control in patients with DM (12).

Rural Canadian communities generally face many challenges with accessibility, availability, and sustainability of healthcare services and providers compared to urban Canadian communities (13). SDOH, including living in rural residences, is associated with increased rates

of DM and related complications (9). T2D is a growing concern for many Canadians, and its complications, if left untreated, are life-threatening (3). Despite many efforts, the rates and complications of T2D continue to rise, especially in rural Canada, given the social disparities discussed above (13). Therefore, it is important to develop a cost-effective model to address the inaccessibility of healthcare services to manage those living with T2D while providing patient-centred care. One such model could potentially be telemedicine (14).

Telemedicine

According to the Institute of Medicine, telemedicine is defined as "the use of electronic information and communications technologies to provide and support health care when distance separates the participants" (15). Telemedicine became increasingly prevalent during the COVID-19 pandemic due to the increased risk of spreading infection and is predicted to remain a popular means of providing care (14). There is a growing role for telemedicine use in managing both acute and chronic conditions and telemedicine is shown to be non-inferior to in-person medicine practices (14).

There are many advantages and disadvantages to implementing a telemedicine model. Advantages of telemedicine include convenience, cost-effectiveness, time-effectiveness, accessibility to healthcare services, improved quality of care, enhanced preventative care, and reduced infection spread (16,17). Disadvantages of implementing a telemedicine model include security concerns, limited access to the internet and technology, inability to perform physical exams, organisational and implementation difficulties, and potential breakdown of the relationship between the professional and patient (16,17).

In the context of T2D, Lee et al. (2017) classified telemedicine into the following subtypes: tele-education, teleconsultation, telemonitoring, tele-case management and tele-mentoring (18). Although all subtypes were found to successfully reduce HbA1c levels, teleconsultation involving two-way interactive communication between the provider or specialist and the patient to manage T2D, ranked the most effective (18). However, Lee et al.'s (2017) was not specific to a rural setting.

Purpose of Literature Review:

This review aimed to examine the available North American literature to investigate the efficacy of telemedicine, specifically teleconsultations, in managing T2D in rural adults. The possible contribution of this review is to examine the effectiveness and potential implementation of a telemedicine model that may be useful in managing T2D in rural Canadian communities. Additionally, this project may indicate areas of future research on telehealth models in Canadian contexts and, therefore, contribute to future health policies to address the ongoing burden of DM on Canadians and the healthcare system in a cost-effective manner.

METHODS:

Between December 20, 2023, and January 15, 2024, the author carried out a comprehensive search on PubMed using the following search terms: ("Telemedicine" OR "Telehealth" OR "Teleconsultation") AND "Rural" AND ("Diabetes" OR "Type 2 Diabetes Mellitus" OR "Diabetes Mellitus Type 2") NOT ("eHealth" OR "mHealth" OR "apps"), generated 275 results. The "Results by Year" filter applied included articles published between 2012 and 2024 to allow for more up-to-date literature on the topic, given an increase in the use of

telemedicine for managing chronic conditions in recent years (19), resulting in 230 articles. The author used PubMed because it was a comprehensive medical database with peer-reviewed articles. Due to the time limitation and nature of this project, no additional databases were used for the search.

Inclusion Criteria

The author selected studies conducted in rural North American communities for easier transferability and application to rural Canadian populations. Since the average onset of T2D is in adulthood (3), the mean age of participants included was greater than 18 in both male and female populations. All studies included teleconsultation with an endocrinologist and a component of DSME. Clinical trials, implementation studies, observational studies and pilot studies were accepted. Additionally, since serum HbA1c is an important measure in glycaemic control and management (4), HbA1c measures were the required primary outcome in all included articles. Studies with more than 90% of subjects having T2D instead of T1D were accepted.

Exclusion Criteria:

Articles involving mHealth or eHealth were excluded from this literature review. Studies that did not measure HbA1c changes and instead measured patient or physician satisfaction or lifestyle changes alone as the primary outcome of the study were excluded. Lastly, incomplete publications and studies involving DSME alone without an endocrinologist's involvement were not included in this review.

RESULTS:

A total of 230 article titles were evaluated from the PubMed results for relevance to the research question. Articles with titles suggesting urban settings, participants with T1D, eHealth, mHealth, and DSME alone were excluded. Abstracts of 22 articles were reviewed to determine if the inclusion and exclusion criteria were met. Publications not meeting the criteria, incomplete studies or those conducted outside of North America were not read to completion. A total of 11 studies were read in-depth, and those with no endocrinologist involvement, DSME alone, and no HbA1c recordings were excluded from the review, as summarised in Figure 1. A total of six articles met the criteria for inclusion and are reviewed below. All included studies were from the United States.

Use of Telemedicine in Managing Type 2 Diabetes in Rural Communities

Toledo et al. (2012): Telemedicine Consultations: An Alternative Model to Increase Specialist Care in Underserved Rural Communities

In an observational study conducted by Toledo et al. (2012), 25 participants (14 females, 11 males) in rural Pennsylvania with uncontrolled DM (24 with T2D, one with T1D) were recruited (20). Subjects received a 45-minute teleconsultation with an endocrinologist based at an urban centre. Laboratory data was reviewed, medications were managed, and DSME was provided to target their unmanaged hyperglycaemia. A trained nurse accompanied the patient at the rural centre during the appointment (20).

The study found that teleconsultation was successful in reducing HbA1c levels from 9.6% to 8.5% ($P<0.001$) after a median of 18 weeks, and it was well accepted by both patients and PCP (20). Additionally, three quarter of the participants had an absolute decrease in their HbA1c by 0.5%. The study was concluded before the HbA1c of 9 participants was available. All

participants were white, with a mean age of 56, and were referred by their PCP, introducing possible referral bias. There was no comment on the participants' education level (20), which may impact the generalizability of data.

Toledo et al. (2014): Efficacy of the Telemedicine for Reach, Education, Access, and Treatment (TREAT) Model for Diabetes Care

Toledo et al. (2014) then developed the Telemedicine for Reach, Education, Access, and Treatment (TREAT) model to provide video consultation services, multidisciplinary care, and DSME. The clinical study recruited 31 rural Pennsylvanian patients (17 females, 12 males) with T2D and HbA1c greater than 7% who received three teleconsultation visits, three months apart, with an endocrinologist at the urban site and a diabetes nurse to assist at the rural site (21).

Compared to the control group that received usual primary care in the community, there was a larger statistically significant improvement in HbA1c in the telemedicine sample (TREAT group) ($p=0.02$), even with multivariate analysis that accounted for insulin use, BMI, age, sex, and duration of T2D (21). During the teleconsult, insulin therapy was intensified, initiated, or altered for 84% of patients. Severe hypoglycaemia was rare (0.13 events per 30 days per person) (21). Participants were not randomly assigned to the control vs TREAT group, introducing possible assignment bias. TREAT patients were referred by their PCP, introducing possible referral bias (21). Regarding race, 30 participants were white, and one was Native American, with a mean age of 62.8 and no comment on their education level (21), impacting the generalizability of findings.

McLendon et al. (2019): Enhancing diabetes care through care coordination, telemedicine, and education: Evaluation of a rural pilot program

In a pilot program evaluation study by McLendon et al. (2019), 59 participants (47F, 12M) with DM (57 T2D, 2 T1D), greater than 18 years, HbA1c greater than 8% and various education levels were recruited (22). Subjects received in-person DSME from a public health clinical nurse specialist (PHCNS) or a Masters prepared health educator (MPH) at two primary care practices (22). Participants also received monthly follow-ups from the nurse care manager to assist with community referrals, medication assistance, and scheduling telemedicine appointments. Only prioritised participants with HbA1c greater than 9% received at least two endocrinology visits via telemedicine facilitated by the PHCNS (22). This was due to a delayed start in securing an endocrinologist provider and internet connection issues at the primary care clinic. Therefore, not all participants received a teleconsult visit (22), which could impact the generalizability of findings.

The study found a statistically significant decrease in HbA1c by 0.83% ($p=0.002$) and a mean total reduction in cholesterol and blood pressures (22). There was a statistically significant correlation between change in HbA1c in participants who received a teleconsult verses those who did not ($r=-0.178$). The authors attributed this to the small sample size in the telemedicine group. High DSME scores, patient satisfaction, and PCP satisfaction were also evaluated (22).

Davis et al. (2020): Mississippi Diabetes Telehealth Network: A Collaborative Approach to Chronic Care Management

In the study by Davis et al. (2020), the type of DM was not specified in the article (23). The authors of that study were contacted by the writer and confirmed that all participants had T2D. The study recruited 171 rural Mississippi patients over the age of 18 with T2D and HbA1c

greater than 7%. The withdrawal rate was 32.7%, resulting in 115 participants (79 females, 36 males) completing the study, leading to attrition bias (23). In this study, participants were provided a tablet with free wireless internet access and a glucometer. At baseline, three-month, six-month and 12-month intervals, participants underwent histories, physical exams, foot exams, and lab tests (23). Using the tablets, they received daily brief diabetes education sessions and had access to specialists, including endocrinologists, ophthalmologists, and dietitians.

The study found that baseline HbA1c (mean: 9.5) levels were greater than the subsequent HbA1cs (mean at three months: 7.7, mean at six months: 7.8, mean at nine months: 7.9 and mean at 12 months: 7.9) ($P<0.001$). The study found that the maximum benefit was achieved in three to four months and maintained at 12 months (23).

Kobe et al. (2020) Implementation of an Intensive Telehealth Intervention for Rural Patients with Clinic-Refractory Diabetes

Kobe et al. (2022) examined the implementation of an Advanced Comprehensive Diabetes Care (ACDC) intervention for rural refractory T2D with HbA1c greater than 8.5% using telemedicine for DSME and specialist-guided medication management (24). The study was conducted at seven Veterans Health Administration (VHA) sites in the USA. For six months, 230 participants (95% males, 5% females) in various rural sites received two telehealth sessions per month by a home telehealth (HT) nurse who reviewed data, determined medication adherence, and provided DSME and support (24). The HT nurse then reported the data to an endocrinologist or pharmacist to help with medication management. There was no direct contact between the patient and the medication manager. The study found that HbA1cs improved by an average of 1.43% (95% confidence interval (CI), -1.64 to – 1.21; $p<0.001$) at six months and were maintained at 12 months and 18 months (24). The study used pre-existing VHA HR services and

equipment (24), which may decrease the generalizability of results to populations without a pre-existing virtual model in place. There was increased patient self-care and glycaemic control. However, there was a moderate increase in workload for HT nurses and clinicians with the implementation of this program (24).

Santen et al. (2022) Intensive, telemedicine-based, self-management program for rural, underserved patients with diabetes mellitus: Re-entry of retired endocrinologists into practice

A recent study by Santen et al. (2022), based in rural Virginia, utilised endocrinologists returning from retirement to provide care to rural patients with uncontrolled DM (94.6% T2D and 3.6% T1D) via telemedicine. Two hundred sixty participants recruited were over the age of 18, with an eGFRs greater than 45 ml/min and HbA1cs greater than 8% for longer than six months, and were competent with a telecare metre and continuous glucose monitor (25). A total of 84% of patients used insulin, while 16% used oral medications alone to manage their DM. For six months, each participant received weekly tele-visits with the endocrinologist for intensive glucose control management and DSME from a certified diabetes care and education specialist (CDCES) (25). The referring PCP was responsible for completing a history and physical exam, ordering blood work, and managing lipids and blood pressure (25).

The authors found a significant decrease in average HbA1c levels from $10.3 \pm 1.94\%$ to $7.78 \pm 1.51\%$ ($p < 0.0001$) in the 139 patients who completed the study over six months (25). Additionally, this study found that most of the participants were able to maintain their HbA1cs on their follow-up appointment 16 months later (25)**.** The study had a high dropout number of 79 participants due to a lack of motivation to continue the program or return phone calls, which may have introduced attrition bias. All participants were referred by their PCP (25), which may have introduced referral bias.

DISCUSSION:

Use of Telemedicine in Managing Type 2 Diabetes in Rural Communities

T2D in rural Canada is a growing burden for both individuals and the healthcare system (8). The purpose of this project was to review the literature for studies that evaluated the effectiveness of telemedicine in managing T2D in rural communities by making endocrinology consultations more accessible. Six studies of rural populations published in the US were included in the review. No Canadian studies were identified. Participants in the research studies were adults with DM (majority T2D) belonging to rural communities. All studies involved consultation with an endocrinologist based at an urban centre with a DSME component provided by the endocrinologist or diabetes educator.

The results from this literature review suggested that telemedicine was effective in reducing HbA1c in DM patients in rural settings. All studies in this review found significant improvements in patients' HbA1c after their specific interventions, as summarised in Table 1. However, many factors should be considered when interpreting the findings, including the strength of evidence produced by the studies. A review of the existing literature indicates a need for a more rigorous study design. The current literature generally involves studies with small numbers of participants and non-randomized control trial study designs. Except for Toledo et al.'s (2014) study, the studies reviewed did not include a control group (20, 22-25). Despite Toledo et al. (2014) using a control group in their study, participants were not randomly assigned but referred by their PCP. Therefore, it is important to be cautious when attributing a causative effect of teleconsultation with improved HbA1c in the study. The lack of control groups did not adequately account for confounding variables and selection bias.

Referrals to the programs in most studies were made by participants' PCP, which could introduce referral biases. PCPs may have referred patients they believed would follow through with the program. Despite this, in the studies conducted by Davis et al. (2020) and Santen et al. (2023), there was a 32.7% and 30.4% withdrawal rate, respectively. These high dropout rates may have introduced nonresponse bias, which could have skewed the results of this study and affected its generalizability.

Additionally, the small sample sizes and lack of heterogeneity may have impacted the generalizability to rural Canadian populations, including Indigenous people living in rural areas, which comprise of 60% of the total Indigenous population (10). For example, in Toledo et al. (2012), Toledo et al. (2014), Kobe et al. (2022), and Santen et al. (2023), 100%, 96%, 80% and 81% of participants were white, respectively. With the exception of one participant out of 30 in Toledo et al.'s (2014) study, no studies included Indigenous participants.

McLendon et al. (2019) and Santen et al. (2023) commented on the education level of participants involved in their studies. In McLendon et al.'s (2019) study, 19 had less than a high school education, 17 had a high school education, and 19 had a postsecondary education. In Santen et al. 's (2023) study, more than 90% had less than a high school education. The remaining studies did not factor in the patient's education level (20, 21, 23, 24). Outcomes may be affected by the participants' health literacy and ability to adhere to and comply with the self-management recommendations from the endocrinologist or diabetes educator (26).

The studies included in this literature review vary in terms of their study designs, summarised in Table 1. Most studies involved televisits between the patient and the endocrinologist for review of lab data, medication review or changes, and self-management education (20–23,25). However, in Kobe et al. (2022)'s study, the HT nurse communicated

reports to the endocrinologist or pharmacist using telemedicine, who then advised medication changes without a televisit directly with the patient. All studies involved diabetes educators (usually nurses) located at the rural sites to provide DSME and facilitate televisits with the endocrinologist at the urban sites (20-25).

Advantages of Telemedicine for Type 2 Diabetes Management in Rural Communities

Siminerio et al.'s (2014) study found high patient satisfaction with distanced care and improved behavioural and psychosocial outcomes such as lifestyle changes, patient empowerment, and reduced distress around T2D diagnosis and management using the TREAT model (27). In a non-randomized study by Siminerio et al. (2023), behavioural and psychosocial outcomes were measured using self-reported instruments, including the Summary of Diabetes Self-Care Activities Measures (SDSCA), the 17-item Diabetes Distress Scale (DDS17), the Eight-item Diabetes Empowerment Scale - Short Form (DES-SF) and, the telehealth Usability Questionnaire (TUQ) (28). All participants in the experimental group reported high levels of acceptance (TUQ) with telemedicine for the delivery of DSME (28). Participants who achieved their DSME self-management goals also showed a reduction in diabetes distress (DDS17) and improved dietary intake (SDSCA) (28). Toledo et al. (2012) and Mclendon et al. (2019) also found high patient and provider satisfaction with teleconsultation in managing DM in rural adults. Additionally, participants in the Kobe et al.'s (2022) study reported increased self-care and glycaemic control awareness. However, HT nurses and clinicians reported a moderate increase in workload with the telemedicine model (24).

Research and the use of telemedicine have greatly expanded during the COVID-19 pandemic and are predicted to remain as such (14). A systematic review by Adil et al. (2019)

concluded that telemedicine was cost-effective in managing DM patients across different settings, including telemonitoring and teleconsulting, while providing adequate healthcare (29).

Findings from this literature review suggest improvement in HbA1c with teleconsultation with an endocrinologist and DSME, although results should be interpreted cautiously. Taken together, these findings indicate that telemedicine may improve access to healthcare services, reduce patients' travel time and costs, enhance self-care behaviours, reduce diabetes distress, increase self-empowerment (27,28,30) as well as improve HbA1cs post-intervention (20, 20, 22–25)

Barriers to Telemedicine for Type 2 Diabetes Management in Rural Communities

Although telemedicine may be effective in managing T2D in rural communities, there are many barriers to the implementation of a telemedicine model. The cost and time associated with the implementation of a telemedicine program, as well as its acceptance, availability, security, and technical difficulties, could pose barriers to this model (31). Kobe et al. (2022) used pre-existing VHA HR services and equipment for their study at seven VHA sites in the United States (24). Therefore, the results from Kobe et al.'s (2022) study may not generalize to other rural populations without pre-existing virtual services and its acceptance.

Limitations and future directions

A major limitation of this literature review is the lack of Canadian studies on this topic. However, all studies in this review were confined to rural North America to allow for easier transfer to Canadian rural settings. Although all studies found significant improvements in their participants' HbA1c levels post-telemedicine intervention, they were largely observational,

implementational or longitudinal cohort studies that lacked control groups (21). Studies with more rigorous methodological components (control groups and random assignment) are required to fully evaluate the effectiveness of telemedicine in managing T2D. Given the high rates of T2D in rural Canadian populations, studies including Indigenous and Northern communities are required to adequately determine the value of telemedicine interventions in the Canadian context.

The use of Physician Assistants (PAs) in diabetes care using telemedicine is currently lacking. PAs increase accessibility of care, decrease wait times and allow continuity of care with their extensive knowledge, competency and scope of practice (32). Therefore, using PAs working in endocrinology in a diabetes telemedicine model could be explored in future studies. As telemedicine continues to become more accepted and utilised within healthcare systems (14), supplementing PA education curriculums with telehealth training could prove essential. Shani et al. (2022) developed a telehealth training program as part of the PA education model to prepare PA students for this evolving field of medicine in the United States (33). Similar telehealth training should be explored in PA programs in Canada.

CONCLUSION:

According to the relevant studies included in this literature review, teleconsultation with an endocrinologist combined with DSME is shown to be effective in reducing HbA1c in North American rural adults (20-25). Future research in Canada should explore the potential for telemedicine in managing T2D in rural settings, given the high rates of diabetes in these areas and the significant burden that the disease represents on individual patients and healthcare systems (3, 8,13).

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APPENDIX

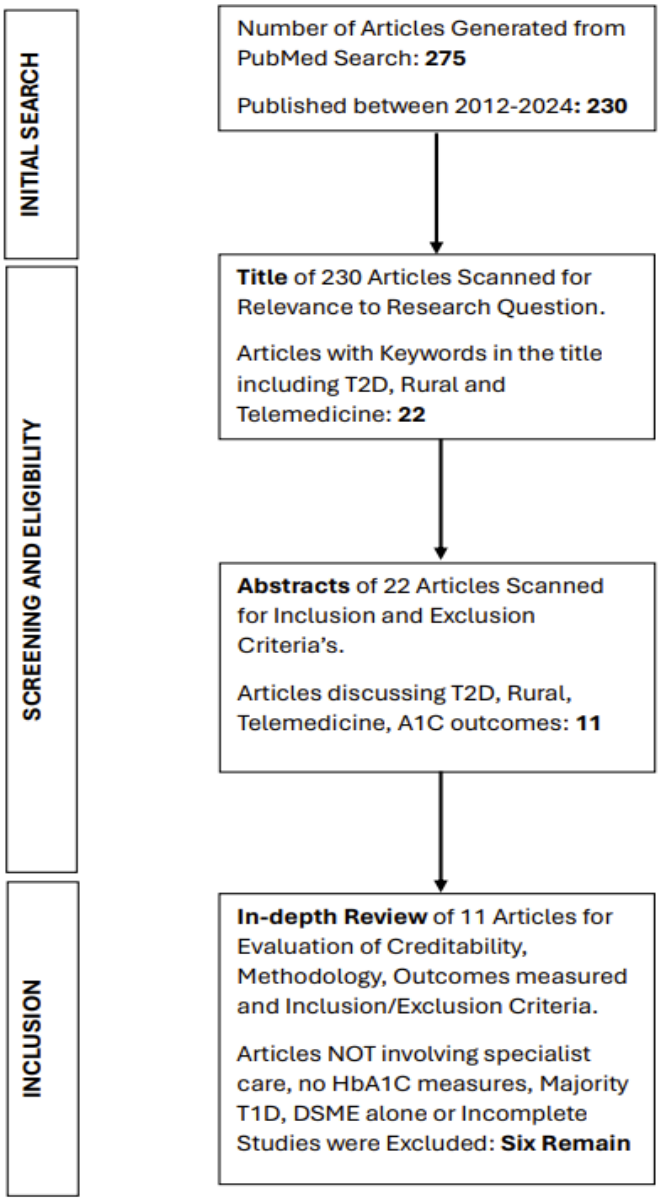

Figure 1: Summary of the search results, screening, eligibility and inclusion of articles for this literature review.

Table 1: Summary of the six articles selected for this literature review, including their inclusion criteria, sample size, gender, race, mean age, education level, type of diabetes, outcomes measured, design overview, results and conclusions.

Article	Methods	Results	Conclusion
Santen et al (2023) **Intensive, telemedicine-based, a self-management program for rural, underserved patients with diabetes mellitus: Re-entry of retired endocrinologists into practice** Clinical Intervention Study Rural Virginia	**Inclusion Criteria**: uncontrolled DM, insulin requirement, age >18 years, eGFR>45 ml/min, competence with telecare metre and continuous glucose monitoring, HbA1c>8% for > six months **N:** 260 referred, 139 completed, 42 still being followed, 79 dropped out **Gender**: 60% F, 40% M **Race**: 81% White, 12% Black and 7% Hispanic **Mean age**: 55.9 **Education:** > 90% had less than a high school education **DM:** 96.4% T2D, 3.6% T1D **Insulin dependence:** 84% **Medication management:** 16% **Measures:** HbA1c **Design:** Weekly appointments with an **endocrinologist** for six months. A certified diabetes care and education specialist (CDCES) provided DSME and coordinated care. Referring NP/physicians took histories, physical exams, and ordered lab work as well as managed lipids/blood pressure.	HbA1c in the 139 participants who completed the program decreased from 10.3 +/- 1.94% to 7.78 +/- 1.51% ($p<0.0001$). HbA1c was maintained at 16-month follow-up for most patients.	Teleconsultations by retired endocrinologists in urban centres help improve and maintain HbA1c in rural DM patients
Kobe et al. (2022) **Implementation of an Intensive Telehealth Intervention for Rural Patients with Clinic-Refractory Diabetes** Mixed-methods implementation study 7 Veterans Health Administration (VHA) sites in US	**Inclusion criteria**: clinic-refractory, uncontrolled T2D adults, HbA1c>8.5%, rural based on rural-urban commuting area (RUCA) scores. **N**: 230 **Gender**: 95% M, 5% F **Race**: 80% White, 14% Hispanic/Latinx **Mean age**: 59 **DM:** all T2D. **Primary measure**: HbA1c **Design:** ACDC telehealth intervention lasted 6 months. Participants received biweekly 30-minute sessions with HT nurse to review Self-Monitoring Blood Glucose (SMBG) and medication management as well as deliver DSME. The HT nurse reported data to the medication manager **(pharmacist/ endocrinologist)** and medication changes were made accordingly. Used pre-existing VHA HT services/equipment.	Improvement in HbA1c from 9.65% to 8.14% at six months, maintained at 12 and 18 months. Participants reported increased self-care and glycaemic control awareness.	ACDC delivered through telemedicine improved glycaemic control in previous clinically refractive T2D patients
Davis et al. (2020) **Mississippi Diabetes Telehealth Network: A Collaborative Approach to Chronic Care Management** Prospective, longitudinal cohort study Rural Mississippi	**Inclusion Criteria**: Rural health clinic, age >18 years old, HbA1c>7% **N:** 171 - 56 (withdrew) = 115 **Gender**: 79 F, 36 M **Race**: White and Black. **Mean age**: 53.6 years **DM:** T2D **Primary Measure:** HbA1c **Design**: At baseline, three months, six months, nine months and 12 months - Participants received history, physical, foot exam, and lab tests. Participants were provided tablets with free wireless internet access and a glucometer. Access to specialty care to **endocrinologists, ophthalmologists, diabetic educators, and dieticians.** Daily, brief diabetes education session on a tablet. Individual contact with **RN** to discuss the plan and provide further DSME (at rural site).	Baseline HbA1c was greater than subsequent HbA1cs ($p<0.001$) at three months, six months, nine months and 12 months. Mean at three months: 7.7, mean at six months: 7.8, mean at nine months: 7.9 mean at 12 months: 7.9. Maximum benefit was achieved after three to four months and maintained at 12 months	Telehealth models provided for better communication between providers and patients and management of DM in rural populations with improved HbA1c measures.

Article	Methods	Results	Conclusion
McLendon et al (2019) **Enhancing Diabetes Care Through Care Coordination, Telemedicine, and Evaluation: Evaluation of a Rural Pilot Program** Pilot program study Rural Southeast Georgia	**Inclusion Criteria**: age>18 years, T2D/T1D, active enrolment in designated clinic, HbA1c>8% **N:** 59 **Gender**: 47 F, 12 M **Race**: 24 Black, 33 White, three Hispanic **Mean age**: range 21 to 76 years **Education:** 19 participants had less than high school, 17 participants completed high school, 19 participants completed post-secondaries, four no response **DM:** 57 T2D, 2 T1D **Measures:** pre/post labs, HbA1c, total cholesterol, BMI, systolic BP, diastolic BP, DSME scores **Design**: 12 months long at two primary care practices. Public health clinical nurse specialist (PHCNS)/ masters prepared health educator (MPH) provided weekly DSME classes in person. Monthly telephone follow-up with nurse care manager for community referrals, assistance with medications and telemedicine scheduling. PHCNS also facilitated telemedicine visits with the **endocrinologist**. Participants whose HbA1c>9% were prioritised and received a minimum of two endocrinology visits (n=23).	Statistically significant decrease in HbA1c by 0.83% (p=0.002). Mean total cholesterol and BP were also significantly reduced. A slight correlation between HbA1c between participants who received telemedicine endocrinology consultation vs those who didn't. (r=-0.178).	Telemedicine is cost effective and efficient at improved HbA1c, hospital utilisation, personal/institutional costs.
Toledo et al (2014) **Efficacy of the for the Reach, Education, Access and Treatment (TREAT) Model for Diabetes Care** Clinical study Pennsylvania	**Inclusion Criteria**: T2D, HbA1c>7%, rural **N:** 31 enrolled, two withdrew, four were lost to follow-up on **Gender**: 12 M, 17 F **Race**: 30 White, one Native American **Mean age**: 62.8 **Education:** not included **DM:** all T2D **Measures:** HbA1c **Design:** TREAT group: Participants received teleconsult from an **endocrinologist** based at the urban site at baseline, three months and six months with a diabetes nurse educator at the rural site. Control group: usual care from PCP in the same community.	There was a significant improvement in HbA1 in the TREAT group compared to the control group (p=0.02) with and without multivariate analysis accounting for insulin use, BMI, age, sex and duration of diabetes. Severe hypoglycaemia was rare (0.13 events/30 days/person).	HbA1c was reduced in the TREAT group with teleconsultation and medication management by an endocrinologist at the urban centre
Toledo et al (2012) **Telemedicine Consultations: An Alternative Model to Increase Access to Diabetes Specialist Care in Underserved Rural Communities** Observational study Pennsylvania	**Inclusion Criteria**: Patients with DM who failed treatment under the care of their PCP. **N:** 25 patients, seven providers **Gender**: 14 F, 11 M **Race**: White **Mean age**: 56 **Education:** not included **DM:** 24 T2D, 1 T1D **Measures:** HbA1c, patient and provider satisfaction **Design**: participants referred by PCP, received one 45-minute teleconsultation with an **endocrinologist** at an urban site for interview, lab data review and management which included medication changes, lifestyle modifications, self-monitoring of BG and lab tests. Nurse at the rural site helped carry out the process and provided DSME.	Mean HbA1c improved from 9.6 +/- 0.4% to 8.5% (p<0.001, paired t-test). ¾ patients had absolute decrease in HbA1c by at least 0.5%.	Teleconsultation with an endocrinologist and diabetes education supported by a nurse at the rural site is shown to be effective in managing hyperglycaemia.